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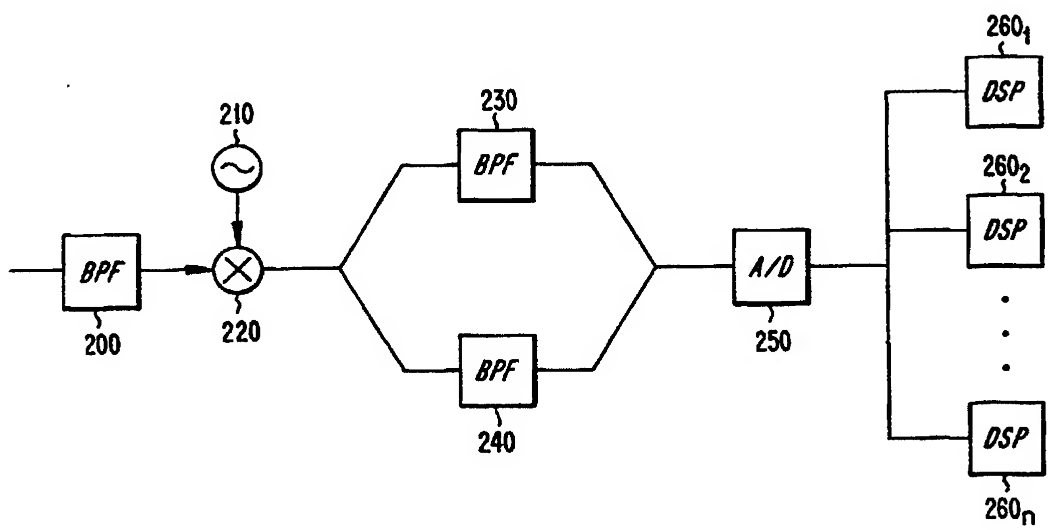

(57) Abstract

A wideband receiver is provided for fully covering a desired band with only one mixer and one local oscillator. The wideband receiver advantageously utilizes the inherent aliasing characteristics of the sampling process taking place in the analog-to-digital converter to achieve full coverage of the desired band. More particularly, the wideband receiver is directed to fully covering the A-band of the AMPS frequency plan by analog-to-digitally converting two separate parts of a spectrum input to the wideband receiver where said spectrum has a total bandwidth greater than the Nyquist frequency of the analog-to-digital converter without any individual frequency transposition of each spectra part before being input to the analog-to-digital converter. The analog-to-digital converter aliases the transposed desired separate frequency bands to fulfill the Nyquist criteria even when a sampling frequency of the analog-to-digital converter is less than twice the bandwidth of the spectrum. As a result, the wideband receiver minimizes the number of analog parts used so that the wideband receiver is smaller, consumes less power and has a higher manufacturing yield.

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AMPS A-BAND SINGLE SUPERHET

BACKGROUND

The present invention is directed to a wideband receiver for providing full coverage of a desired band by advantageously utilizing aliasing characteristics of the sampling process. More particularly, the present invention is directed to a device and method for a wideband single superheterodyne (superhet) receiver for full A-band coverage in the Advanced Mobile Phone Service (AMPS) frequency plan with only one mixer and one local oscillator.

Presently, base station receivers for AMPS and D-AMPS are usually designed as double superheterodyne receivers which perform an analog downconversion of each individual narrowband (approximately 30 kHz) channel to a fixed (common for all channels) intermediate frequency. In other words, the same fixed intermediate frequency is used irrespective of which channel the receiver is tuned to. Analog-to-digital conversion of each narrowband channel is then performed and subsequent signal processing is done digitally.

An example of a conventional double superheterodyne receiver system for n channels is illustrated in Figure 1. In Figure 1, desired bands are received by a first bandpass filter 10 which is connected to first pairs of first local oscillators $20_1, 20_2, \ldots 20_n$ and first mixers $30_1, 30_2, \ldots 30_n$ so that each received channel is converted to a common fixed intermediate frequency. A plurality of second bandpass filters $40_1, 40_2, \ldots 40_n$ are connected to the first mixers $30_1, 30_2, \ldots 30_n$, respectively for passing through narrowband channels of approximately 30 kHz. The outputs of the second bandpass filters $40_1, 40_2, \ldots 40_n$ are connected to second pairs of second local oscillators $50_1, 50_2, \ldots 50_n$ and

second mixers $60_1, 60_2, \ldots 60_n$ for performing an analog down conversion of each individual narrowband channel from the second bandpass filters $40_1, 40_2, \ldots 40_n$. The outputs of the second mixers $60_1, 60_2, \ldots 60_n$ are connected to a plurality of third bandpass filters $70_1, 70_2, \ldots 70_n$. Analog-to-digital converters $80_1, 80_2, \ldots 80_n$ perform analog-to-digital conversion of each narrowband channel and then signal processing is performed digitally by a plurality of digital signal processors $90_1, 90_2, \ldots 90_n$.

It is also known to use a wideband receiver in which the whole frequency spectra allocated to the operator is downconverted to a suitable intermediate frequency interval and then converted from analog to digital. The selection of each narrowband channel and further processing is then done digitally. Figure 2 illustrates an example of this conventional wideband receiver where a signal is input to a first bandpass filter 15 and then downconverted to the intermediate frequency interval by a local oscillator 25 and a mixer 35. The output of the mixer 35 is input to a second bandpass filter 45 and then converted to a digital signal by the analog-to-digital converter 85. The output of the analog-to-digital converter 85 is input to a plurality of digital signal processors $95_1, 95_2, \ldots 95_n$ for further processing.

In the application of wideband receivers to the AMPS frequency plan, certain difficulties exist which prevent sufficient resolution from being achieved for the required dynamic range of the wideband receiver. To better illustrate these problems, an overview of the AMPS frequency is provided below in Table 1.

TABLE 1

A''	824-825 MHz	(1 MHz bandwidth)
A	825-835 MHz	(10 MHz)
B	835-845 MHz	(10 MHz)
A'	845-846.5 MHz	(1.5 MHz)
B'	846.5-849 MHz	(2.5 MHz)

As seen in Table 1, the full A- or B-band utilizes 12.5 MHz bandwidth each. Because of the distribution of the bands, a wideband receiver needs to cover 22.5 MHz bandwidth (824-846.5 MHz) for the full A-band and 14 MHz bandwidth for full B-band coverage (835-849 MHz), respectively. Because only the A- and B-bands were originally allocated for mobile telephone use, the later addition of the extended bands A''-, A'- and B'-bands caused the differences in the bandwidth which are necessary for fully covering the A- and B-bands.

To achieve full B-band coverage in a wideband receiver, a sampling frequency of at least 28 MHz (2 x 14 MHz, which is the bandwidth for full B-band coverage) is needed. The 28 MHz sampling frequency is within the limits of the present technology for sufficient resolution to achieve the required dynamic range for the wideband receiver. However, to achieve full A-band coverage, a sampling frequency of more than 45 MHz (2 x 22.5 MHz, the bandwidth for full A-band coverage) is required. This sampling frequency is beyond the present technology for an analog-to-digital converter with sufficient resolution.

In order to overcome this problem of insufficient

resolution, a wideband receiver as illustrated in Figure 3, for example, has been proposed. In the wideband receiver of Figure 3, a first bandpass filter 100 receives the A''-, A'- and A-bands and is connected to a pair of first local oscillator 110 and a first mixer 120 which frequency transpose the A-, A'-, and A''-bands to an intermediate frequency band. The output of the first mixer 120 is connected to second and third bandpass filters 130 and 131 for passing the A- and A''-bands and the A'-band therethrough, respectively. The outputs of the second and third bandpass filters 130 and 131 are connected to pairs of second and third local oscillators 140 and 141 and second and third mixers 150 and 151. The outputs of the second and third mixers 150 and 151 are input to fourth and fifth bandpass filters 160 and 161, respectively. The frequency of the second local oscillator 140 and the frequency of the third local oscillator 141 are chosen so that the A''- and A-bands, and the A'-band, respectively, are transposed to a nearly continuous frequency band having a total bandwidth of less than approximately 15 MHz. As a result, the required sampling frequency becomes 30 MHz (2 x the total bandwidth of approximately 15 MHz). The nearly continuous frequency band is input to an analog-to-digital converter 170. The output of the analog-to-digital converter 170 is input to a plurality of digital signal processors $180_1, 180_2, \ldots 180_n$. The frequencies of the second and third local oscillators 140 and 141 must be chosen so that a sufficient guardband is provided which prevents the requirements on the anti-aliasing filters from being too stringent.

Figure 4 illustrates another proposed solution which provides a sufficient resolution for the required dynamic range of the wideband receiver. In Figure 4, a first bandpass filter 105 receives the A-, A'-, and A''-

bands and passes these bands through to a pair of a local oscillator 115 and a first mixer 125. The transposed A- and A''-bands are input to a second bandpass filter 135 and the transposed A'-band is input to a third bandpass filter 136. The outputs of the second and third bandpass filters 135 and 136 are input to second and third mixers 155 and 156 which are connected to a common local oscillator 145 so that $F_{in}-F_{Lo}$ from one mixer and $F_{Lo}-F_{in}$ from the other mixer are used. The outputs of the second and third mixers 155 and 156 are input to fourth and fifth bandpass filters 165 and 166 to provide a nearly continuous frequency band to an analog-to-digital converter 175. The output of the analog-to-digital converter 175 is input to a plurality of digital signal processors 185_1, 185_2, ...185_n. In this wideband receiver, one of the bands is inverted, while the other band is non-inverted, but the inverted band is corrected by the digital signal processors 185_1, 185_2, ...185_n.

In both of the wideband receivers proposed in Figures 3 and 4, a double superhet receiver is used with three mixers and at least two local oscillators. The embodiments of the present invention are directed to a wideband single superheterodyne receiver which fully covers a desired band with only one mixer and one local oscillator.

SUMMARY

An object of the present invention is to provide a wideband receiver which fully covers a desired bandwidth of frequencies. More particularly, the present invention is directed to a wideband superheterodyne receiver for providing full coverage of the desired band with only one mixer and one local oscillator.

Another object of the present invention is to utilize an analog-to-digital converter which converts two separate parts of a spectrum, where said spectrum has a total bandwidth greater than the Nyquist frequency of the analog-to-digital converter, and to take advantage of the aliasing characteristics during the sampling process in a positive manner so that the wideband receiver provides full coverage of the desired band.

A still further object of the present invention is to provide full A-band coverage of the AMPS frequency plan by a wideband receiver having only one mixer and one local oscillator.

These objects of the present invention are fulfilled by providing a wideband receiver for full coverage of a desired band comprising a local oscillator operating at a transposing frequency, a mixer connected to said local oscillator for receiving predetermined frequency bands and transposing said predetermined frequency bands to transposed frequency bands in response to said transposing frequency, and an analog-to-digital converter operating at a sampling frequency for aliasing down said transposed frequency bands to achieve full coverage of the desired band. By using the aliasing characteristics of the analog-to-digital converter in a positive manner, the wideband receiver provides full A-band coverage with only one mixer and one local oscillator. Thereby the analog parts of the wideband receiver are minimized so that the wideband receiver is smaller in size, consumes less power and has a high manufacturing yield.

The objects of the present invention are also fulfilled by a method for providing full coverage of a desired band with a wideband receiver comprising the steps of operating a local oscillator at a transposing

frequency, receiving predetermined frequency bands with a mixer and transposing said predetermined frequency bands to transposed frequency bands in response to said transposing frequency, and aliasing down said transposed frequency bands by an analog-to-digital converter operating at a sampling frequency to achieve full coverage of the desired band. This method similarly utilizes the inherent aliasing characteristics of this sampling process taking place in the analog-to-digital converter so that full coverage of a desired band is provided with only one mixer and one local oscillator.

Further scope of applicability of the present invention will become apparent from the detail description given hereinafter. However, it should be understood that the detailed description and specific examples, all indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, wherein:

Figure 1 illustrates a conventional receiver system for n narrowband channels where each channel is processed in a double superheterodyne receiver which converts each narrowband channel;

Figure 2 illustrates a conventional wideband receiver which converts the whole frequency spectra and performs digital processing for n narrowband channels;

Figure 3 illustrates a proposed wideband receiver having three mixers and three local oscillators, making

it possible to convert two separate parts of a spectrum into a nearly continuous frequency band with a bandwidth less than the original spectrum bandwidth;

Figure 4 illustrates a proposed wideband receiver having three mixers and two local oscillators, making it possible to convert two separate parts of a spectrum into a nearly continuous frequency band with a bandwidth less than the original spectrum bandwidth;

Figure 5 illustrates a wideband receiver for an embodiment of the present invention; and

Figure 6 illustrates an example of a frequency plan for the wideband receiver used in an embodiment of the present invention.

DETAILED DESCRIPTION

Figure 5 illustrates a wideband receiver for an embodiment of the present invention. In this embodiment, a wideband, single superheterodyne receiver is provided for full coverage of a desired band with only one mixer and one local oscillator. In Figure 5, a spectrum is input to a first bandpass filter 200 which passes through desired frequency bands. The desired frequency bands passing through the first bandpass filter 200 are input to a mixer 220. The mixer 220 is connected to a local oscillator 210 which operates the mixer 220 at a transposing frequency. By operating the mixer 220 at the transposing frequency, transposed frequency bands are outputted from the mixer 220. The output of the mixer 220 is input to second and third bandpass filters 230 and 240 for passing the transposed frequency bands therethrough. The transposed frequency bands are input to an analog-to-digital converter 250 which converts the transposed frequency bands to digital signals.

In the sampling process, the analog-to-digital converter 250 operates at a predetermined sampling

frequency which aliases down the transposed frequency bands to inverted and non-inverted frequency bands. The output of the analog-to-digital converter 250 is input to a plurality of digital signal processors 260_1, 260_2, ...260_n for further processing of the frequency bands. The digital signal processors 260_1, 260_2, ...260_n can easily process the inverted frequency band aliased down by the analog-to-digital converter 250. For simplicity, only the parts that are essential for the understanding of the function are shown in the figures and mentioned in the description (the filters, mixers, local oscillators, analog-to-digital converters). However, in the actual implementation of the wideband receiver, various additional circuitry as would be obvious to one of ordinary skill in the art is necessary to ensure that sufficient signal-to-noise ratios are achieved, such as different amplifiers for example.

In the present embodiment, aliasing, which is usually thought of as an undesired property, is used in a positive manner to make it possible to design a wideband receiver for fully covering a desired band in a spectrum with only one mixer and one local oscillator. The analog input spectra consists of two desired parts with bandwidths B_1 and B_2 respectively, separated by a non-desired band with bandwidth G_a, where $B_1 + G_a + B_2 > f_{Nyq}$, and where f_{Nyq} is the Nyquist frequency of the analog-to-digital converter 250. The aliasing is used to digitally transpose the part with the bandwidth B_2 so that the digital (after analog-to-digital conversion) spectra consists of two desired parts with bandwidths B_1 and B_2 respectively, now separated by a non-desired band with bandwidth G_d, where $B_1 + G_d + B_2 < f_{Nyq}$. By advantageously utilizing the aliasing characteristics of the analog-to-digital converter 250, a sampling frequency can be used that is within the known

limitations for present analog-to-digital converters (approximately 39 MHz). Thereby, even when the sampling frequency is less than twice the bandwidth of the spectrum, the Nyquist criteria is fulfilled by advantageously utilizing the aliasing characteristics.

When the desired band coverage is for the A-band of the AMPS frequency plan, for example, the wideband single superheterodyne receiver operates as will be described as follows with reference to Figure 6. This example is used to only illustrate the operation of the wideband receiver for the present embodiment and other considerations must be taken into account when actually designing the wideband receiver, such as sample frequency versus data rate, anti-aliasing filter structures, etc., which are neglected in this example. The full A-band is input to the first bandpass filter 200 for passing through the A''-, A-, and A'-bands which include the frequencies of 824-835 and 845-846.5 MHz. These frequency bands are then input to the mixer 220 which is operated by the local oscillator 210 at the transposing frequency of 803 MHz and transposes the A''- and A-bands to between the frequencies of f_1 and f_2 (corresponding to 21 and 32 MHz) and the A'-band to between the frequencies of f_3 and f_4 (which corresponds to 42 and 43.5 MHz) as illustrated in Figure 6. The second bandpass filter 230 passes through the A- and A''-bands between 21 and 32 MHz and the third bandpass filter 240 passes through A'-band frequencies between 42 and 43.5 MHz.

With a sampling frequency of $f_s = 39$ MHz for the analog-to-digital converter 250, the A'-band is aliased down to between 3 and 4.5 MHz (non-inverted) and the A''- and A-bands are aliased down to between 7 and 18 MHz, inverted. Although it is theoretically possible to use a sampling frequency of approximately 33.5 MHz in

this example, the sampling frequency should be higher, near the 39 MHz used in this example, for practical purposes to provide a sufficient guardband. The theoretical minimum sampling frequency can be calculated as follows. By placing f_s between f_2 and f_3 so that $f_3 - f_s = f_s - f_2 - (f_4 - f_3)$ [Equation 1] the "A'-band of the spectrum is made to alias around f_s without overlapping the A''- and A-bands. The A''- and A-bands alias around f_1 such that $f_1 = f_s/2$ [Equation 2]. Thereby, Equation 1 can be rewritten as $2f_s = f_2 + f_4 = f_2 - f_1 + f_4 - f_1 + 2f_1$ [Equation 3]. Because $2f_1 = f_s$ according to Equation 2, the relation $f_s = f_2 - f_1 + f_4 - f_1 = 11$ MHz + 22.5 MHz = 33.5 MHz for this example. The aliased down A-band is included within the frequencies from 3 to 18 MHz with a guardband between 4.5 and 7 MHz. The A- and A''-bands are inverted while the A'-band is non-inverted, but the A- and A''-bands are easily processed by the digital signal processors 260_1, 260_2, ...260_n which receive the output from the analog-to-digital converter 250.

By utilizing the inherent aliasing characteristics of the sampling process which takes place in the analog-to-digital converter 250, a wideband superheterodyne receiver is provided for full A-band coverage with only one mixer and one local oscillator. More generally, by advantageously using the aliasing characteristics, a wideband receiver may be designed for fully covering a desired band with only one mixer and one local oscillator. As a result, the analog parts of the wideband receiver are minimized so that the wideband receiver is smaller, consumes less power, has a higher manufacturing yield and has a reduced manufacturing cost.

The invention being thus described, it would be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from

the spirit and scope of the invention, and all such modification as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

CLAIMS:

1. A wideband receiver for providing full coverage of desired separate frequency bands in a spectrum, comprising:

a local oscillator operating at a transposing frequency;

a mixer connected to said local oscillator for receiving the spectrum and transposing the spectrum to a transposed spectrum in response to said transposing frequency; and

an analog-to-digital converter for aliasing said transposed spectrum of the desired separate frequency bands to fulfill the Nyquist criteria when a sampling frequency of said analog-to-digital converter is less than twice the bandwidth of the spectrum.

2. A wideband receiver according to claim 1, further comprising a first bandpass filter for receiving the spectrum having a plurality of frequency bands and passing through the desired separate frequency bands.

3. A wideband receiver according to claim 1, further comprising a plurality of second bandpass filters for passing through said transposed spectrum.

4. A wideband receiver according to claim 1, wherein the desired separate frequency bands comprise A-, A′- and A′′-bands of the full A-band for the AMPS frequency plan.

5. A wideband receiver according to claim 4, wherein said analog-to-digital converter aliases down said A- and A′′-bands together in an inverted manner and aliases down said A′-band in a non-inverted manner.

6. A wideband receiver according to claim 5, further comprising a plurality of digital signal processors for inverting said A- and A''-bands and processing said A-, A'- and A''-bands.

7. A wideband receiver according to claim 1, further comprising a plurality of digital signal processors for processing said transposed spectrum after being aliased down by said analog-to-digital converter.

8. A wideband receiver according to claim 1, wherein the desired separate frequency bands are allocated in the spectrum where said spectrum has a total bandwidth greater than the Nyquist frequency of said analog-to-digital converter and the wideband receiver is a wideband single superheterodyne receiver.

9. A wideband receiver comprising:

a local oscillator operating at a transposing frequency;

a mixer connected to said local oscillator for transposing a spectrum of first and second bandwidths to a transposed spectrum of said first and second bandwidths in response to said transposing frequency; and

an analog to digital converter for aliasing said transposed spectrum of said first and second bandwidths to fulfill the Nyquist criteria when a sampling frequency of said analog-to-digital converter is less than twice the bandwidth of the spectrum.

10. A wideband receiver according to claim 9, wherein said first bandwidth comprises A- and A''-bands and said second bandwidth comprises an A'-band to provide full A-band coverage of the AMPS frequency plan.

11. A wideband receiver according to claim 9, further comprising:

a first bandpass filter for passing through said spectrum of said first and second bandwidths to said mixer; and

a second bandpass filter for passing through said transposed spectrum of said first and second bandwidths from said mixer to said analog-to-digital converter.

12. A wideband receiver according to claim 9, wherein said analog-to-digital converter aliases down said transposed spectrum for said first bandwidth in an inverted manner and said transposed spectrum for said second bandwidth in a non-inverted manner.

13. A wideband receiver according to claim 9, further comprising a plurality of digital signal processors for inverting said transposed spectrum for said first bandwidth and processing said transposed spectrum for said first and second bandwidths.

14. A wideband receiver for providing full A-band coverage of the AMPS frequency plan, comprising:

a local oscillator operating at a transposing frequency;

a mixer connected to said local oscillator for receiving a spectrum of A-, A′- and A′′-bands for the A-band and transposing said spectrum for said A- and A′′-bands to a first transposed spectrum and said spectrum for said A′-band to a second transposed spectrum; and

an analog-to-digital converter for aliasing said first and second transposed spectrums for fulfill the Nyquist criteria when a sampling frequency of said analog-to-digital converter is less than twice the bandwidth of said spectrum.

15. A wideband receiver according to claim 14, wherein said analog-to-digital converter aliases down said first transposed spectrum to an inverted spectrum and said second transposed spectrum to a non-inverted spectrum.

16. A wideband receiver according to claim 14, further comprising:

a first bandpass filter for passing through said spectrum of said A-, A'- and A''-bands to said mixer;

a second bandpass filter for passing through said first transposed spectrum from said mixer to said analog-to-digital converter; and

a third bandpass filter for passing through said second transposed spectrum from said mixer to said analog-to-digital converter.

17. A method for providing full coverage of desired separate frequency bands in a spectrum by a wideband receiver, comprising the steps of:

(a) operating a local oscillator at a transposing frequency;

(b) receiving the spectrum and transposing the spectrum to a transposed spectrum in response to said transposing frequency by a mixer; and

(c) aliasing said transposed spectrum of the desired separate frequency bands by an analog-to-digital converter to fulfill the Nyquist criteria when a sampling frequency of said analog-to-digital converter is less than twice the bandwidth of the spectrum.

18. A method according to claim 17, further comprising the steps of:

(d) receiving the spectrum having a plurality of frequency bands by a first bandpass filter and passing

through the desired separate frequency bands to said mixer; and

(e) receiving said spectrum from said mixer by a second bandpass filter and passing through the desired separate frequency bands to said analog-to-digital converter.

19. A method according to claim 17, wherein the spectrum comprises a first frequency band for A- and A''-bands and a second frequency band for an A'-band of the full A-band for the AMPS frequency plan.

20. A method according to claim 19, wherein said step (c) aliases down said first frequency band in an inverted manner and said second frequency band in a non-inverted manner.

21. A method according to claim 20, further comprising the steps of inverting said first frequency band and processing said first and second frequency bands by a plurality of digital signal processors.

22. A method for providing full coverage of desired separate frequency bands in a spectrum by a wideband receiver comprising the steps of:

(a) operating a local oscillator at a transposing frequency;

(b) receiving the spectrum of first and second bandwidths and transposing the spectrum of said first and second bandwidths to a transposed spectrum of said first and second bandwidths in response to said transposing frequency;

(c) aliasing said transposed spectrum of said first and second bandwidths by an analog-to-digital converter to fulfil the Nyquist criteria when a sampling frequency

of said analog-to-digital converter is less than twice the bandwidth of the spectrum.

23. A method according to claim 22, wherein said first bandwidth comprises A- and A''-bands and said second bandwidth comprises an A' band to provide full A-band coverage of the AMPS frequency plan.

24. A method according to claim 22, further comprising the steps of:

(d) receiving the spectrum of said first and second bandwidths and passing through said first and second bandwidths to said mixer; and

(e) receiving said transposed spectrum of said first and second bandwidths from said mixer and passing through said transposed spectrum of said first and second bandwidths from said mixer to said analog-to-digital converter.

25. A method according to claim 22, wherein said step (c) aliases down said transposed spectrum for said first bandwidth in an inverted manner and aliases down said transposed spectrum for said second bandwidth in a non-inverted manner.

26. A method according to claim 22, further comprising the steps of inverting said transposed spectrum for said first bandwidth and processing said transposed spectrum for said first and second bandwidths by a plurality of digital signal processors.

27. A method for providing full A-band coverage of the AMPS frequency plan by a wideband receiver comprising the steps of:

(a) operating a local oscillator at a transposing

frequency;

(b) receiving a spectrum of A-, A'- and A''-bands of the A-band with a mixer and transposing said spectrum for said A- and A''-bands to a first transposed spectrum and said spectrum for said A'-band to a second transposed spectrum; and

(c) aliasing said first and second transposed spectrums to fulfill the Nyquist criteria when a sampling frequency of said analog-to-digital converter is less than twice the bandwidth of said spectrum.

28. A method according to claim 27, wherein said step (c) aliases down said first transposed spectrum to an inverted spectrum and said second transposed spectrum to a non-inverted spectrum.

29. A method according to claim 27, further comprising the steps of:

(d) receiving said spectrum of said A-, A'- and A''-bands by a first bandpass filter and passing through said spectrum of said A-, A'- and A''-bands to said mixer;

(e) receiving said spectrum of said A- and A''-bands from said mixer by a second bandpass filter and passing through said first transposed spectrum to said analog-to-digital converter; and

(f) receiving said spectrum of said A'-band from said mixer by a third bandpass filter and passing through said second transposed spectrum to said analog-to-digital converter.

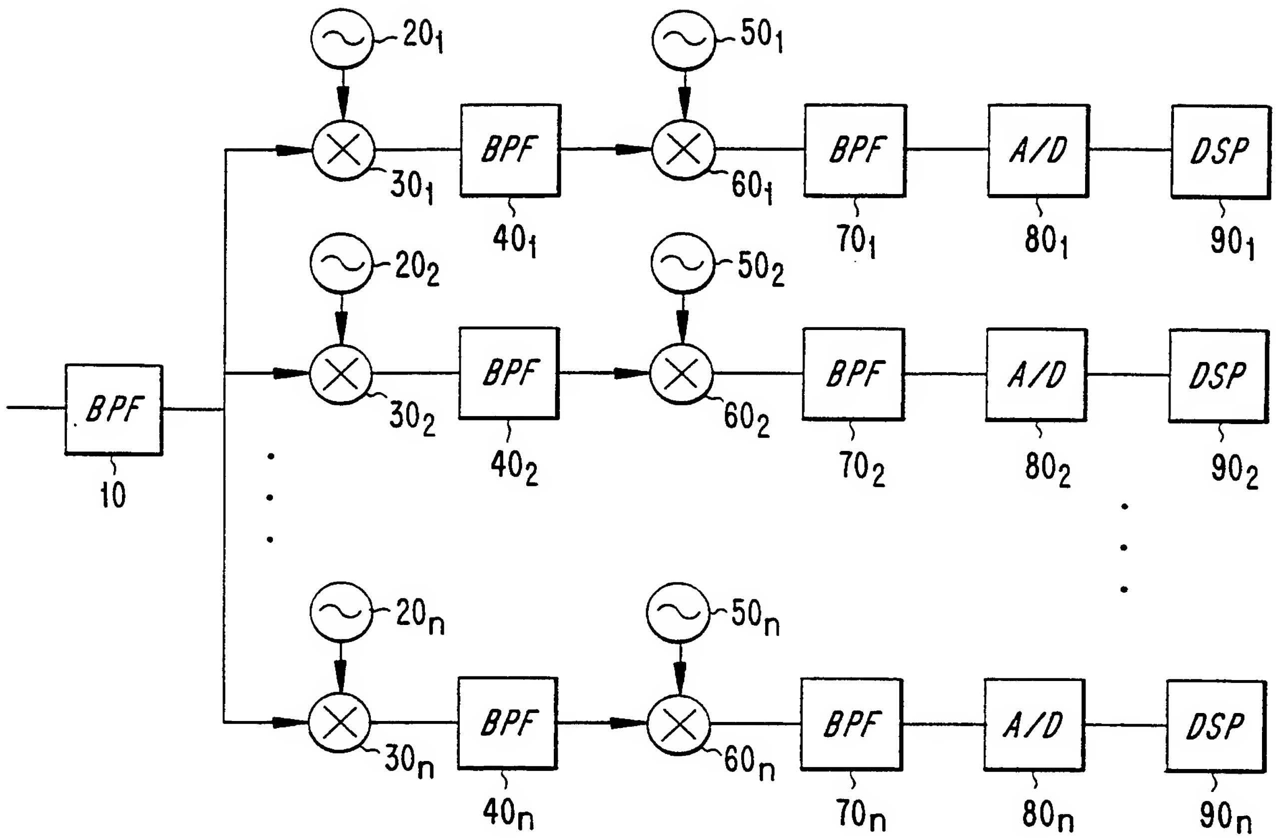

Fig. 1
PRIOR ART

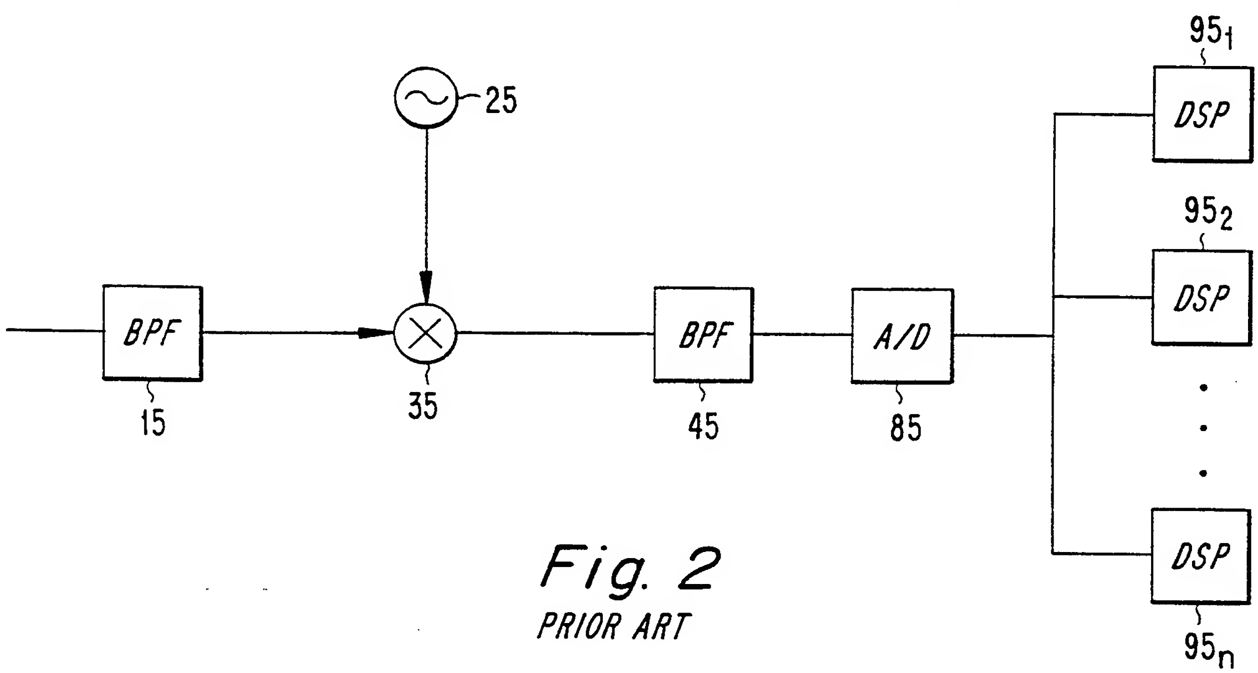

Fig. 2
PRIOR ART

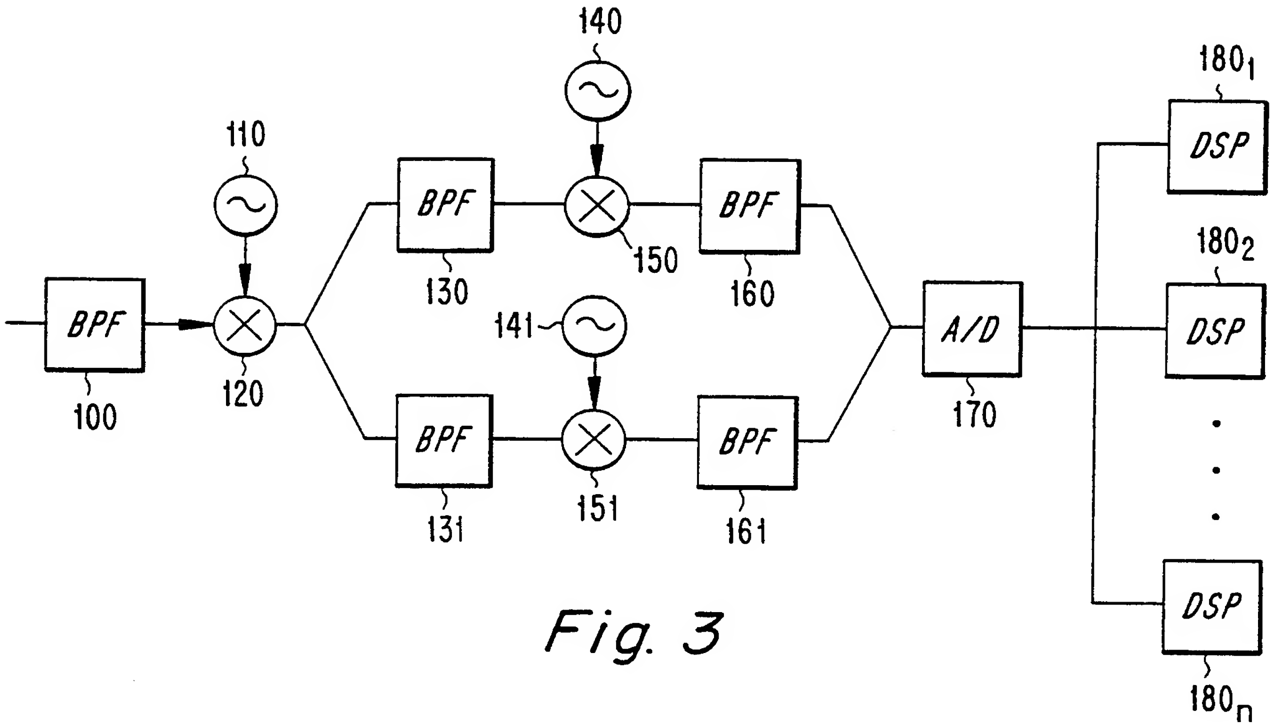
140
180$_1$
110
DSP
BPF
BPF
150
180$_2$
130
160
BPF
141
A/D
DSP
100
120
BPF
BPF
170
131
151
161
DSP
180$_n$

Fig. 3

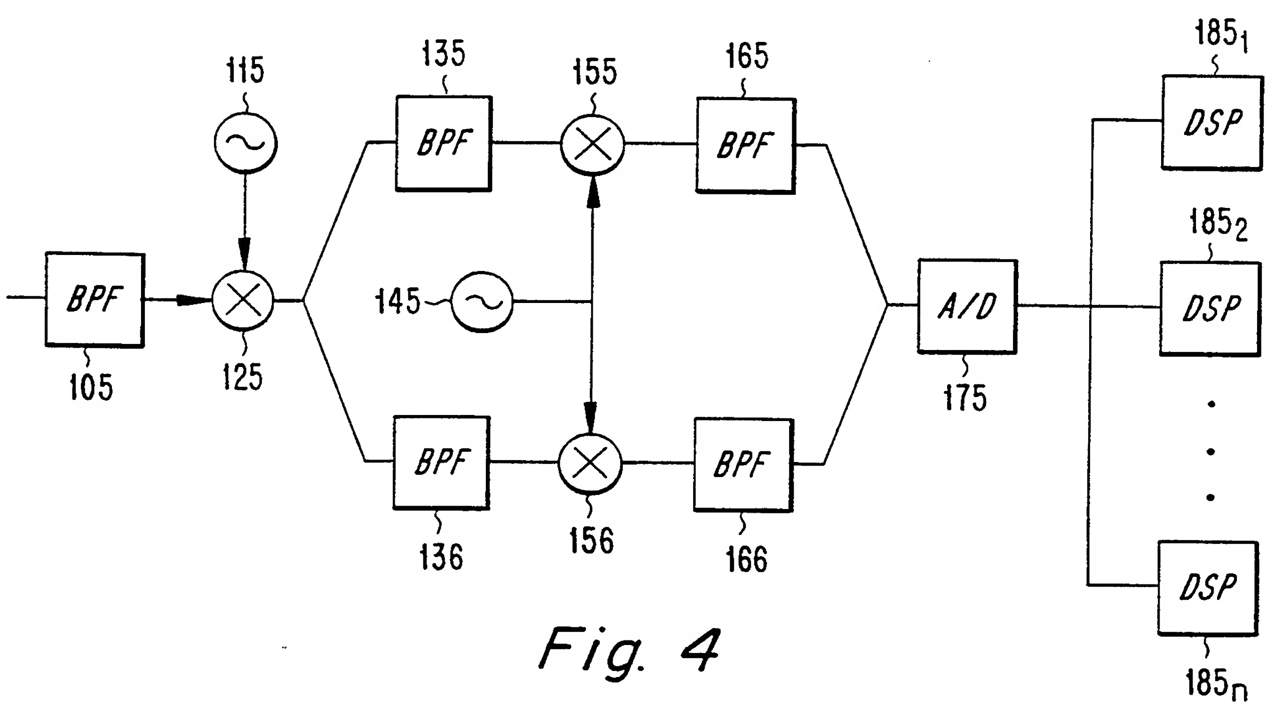
185$_1$
115
135
155
165
DSP
BPF
BPF
185$_2$
BPF
145
A/D
DSP
105
125
175
BPF
BPF
136
156
166
DSP
185$_n$

Fig. 4

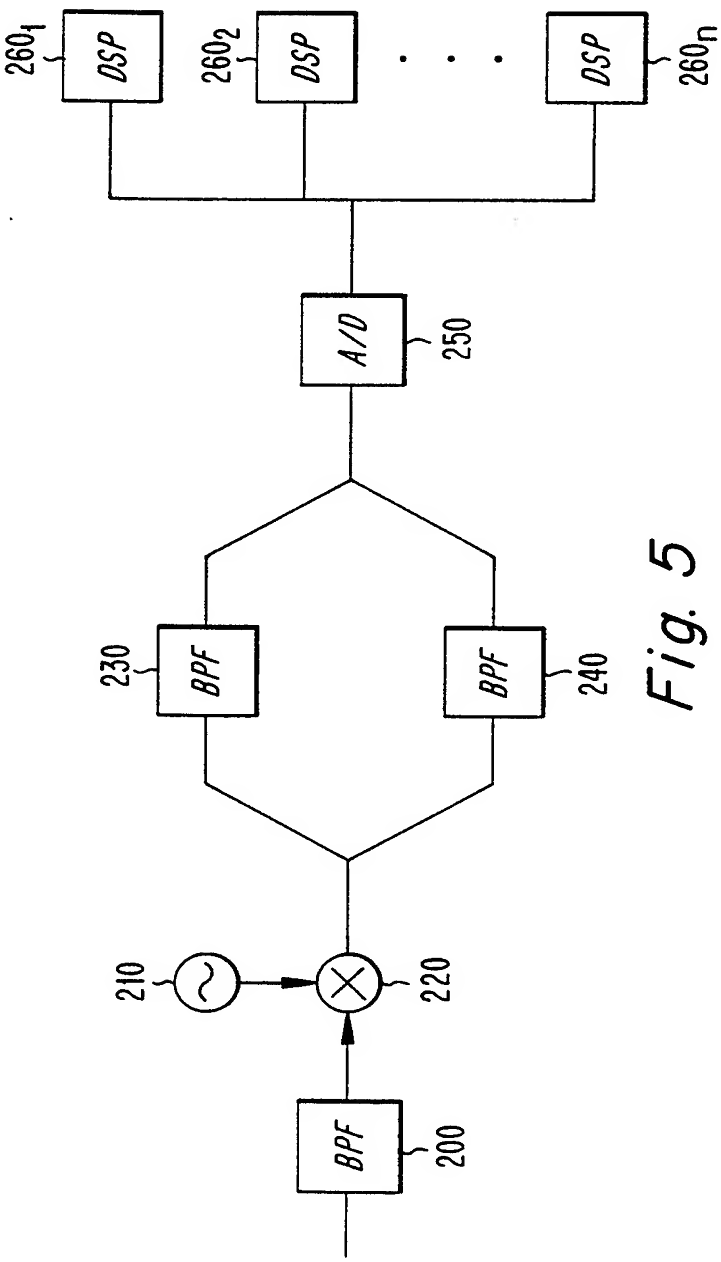
260₁
DSP
260₂
DSP
DSP
260n
A/D
250
BPF
230
BPF
240
210
220
BPF
200

Fig. 5

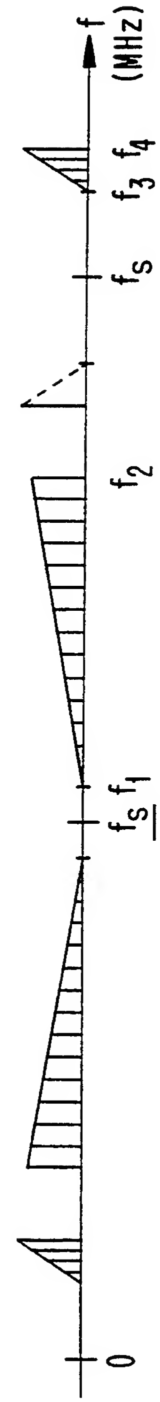
f
(MHz)
f_4
f_3
f_S
f_2
f_1
$\frac{f_S}{2}$
0

Fig. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 96/00961

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B1/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,5 289 464 (WANG) 22 February 1994 see column 2, line 30 - column 3, line 44; figure 1	1,9,14, 17,22,27
A	US,A,5 436 955 (KAEWELL JR. ET AL) 25 July 1995 see column 1, line 7 - line 54	4,10,14, 19,23,27
A	ELECTRONICS ENGINEERING, vol. 63, no. 771, March 1991, WOOLWICH,LONDON,GB, pages 31-38, XP000223926 OLMSTEAD: "The GSM cellular telephone system and its components" see page 36, column 2, line 6 - page 38, column 2, line 8; figures 2,3	1,9,14, 17,22,27

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
24 October 1996	18.11.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Andersen, J.G.

INTERNATIONAL SEARCH REPORT

.mation on patent family members

Internat~~nal Application No
PCT/ ـE 96/00961

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-5289464	22-02-94	AU-A- 648472	21-04-94
		CA-A- 2100901	22-03-94
		EP-A- 0589594	30-03-94
		JP-A- 6204958	22-07-94
US-A-5436955	25-07-95	NONE	